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FIRE EFFECTS ON PLANT NUTRIENT CONTENT IN ARIZONA CHAPARRAL

by
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28-C5-349

FINAL REPORT

FIRE EFFECTS ON PLANT NUTRIENT CONTENT IN ARIZONA CHAPARRAL

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INTRODUCTION

This report summarizes the results obtained from the nutrient analysis of woody plant species at the Battle Flat watershed to date. The project was supported by Coop Aid Agreement No. 28-C5-349.

The project consisted of several major components involving the measurement of pre- and post-fire biomass, evaluation of vegetation cover changes, as well as the measurement of pre- and post-fire nutrient content of shrub live oak (Quercus turbinella) and birchleaf mountain mahogany (Cercocarpus betuloides). Objectives and field procedures were presented in previous reports (Whysong and McCraw 1984, Whysong and McCraw 1985, McCraw 1985). In addition, McCraw (1985) presented the biomass models developed to allow estimation of annual growth, leaf, and total biomass of shrub live oak and mountain mahogany. Whysong and Carr (1987) presented pre-fire vegetation density, frequency and percent composition data as well as the final results from biomass measurements. In addition, they documented post-fire biomass regrowth and shrub canopy cover changes following fire. Preliminary information concerning the nitrogen content of shrub live oak and mountain mahogany were also presented.

This report describes the procedures used and results obtained concerning the nutrient analysis of vegetative material to date.

METHODS

Field Sampling

Prior to the October 1985 burn, collection of material for nutrient analysis was largely restricted to shrub live oak and mountain mahogany as specified in the Coop Aid Agreement. Although the density of mature manzanita (Arctostaphylos pungens) was greater than mountain mahogany (Whysong and Carr 1987), the species was not officially added to the Coop Aid Agreement nor were any provisions made to pay for its measurement. The principal investigator felt it unwise to ignore the nutrient content of manzanita, when it comprised a major portion of the vegetation. Therefore, collection and measurement of manzanita and the planning for subsequent "spot" measurement of other species was initiated shortly before the October 1985 burn and conducted without compensation. Those plant species included for "spot" measurements consisted of: ceanothus (Ceanothus greggii), Wright-'s silktassel (Garrya Wrightii), sugar sumac (Rhus ovata), skunk-brush (Rhus trilobata), rhamnus (Rhamnus crotea), yerba-santa (Eriodictyon angustifolium) and weeping lovegrass (Eragrostis curvula).

Prior to the October 1985 burn, samples for nutrient analysis were collected on a monthly basis in order to characterize nutrient content during the growing season prior to burning. Primary emphasis was to be on nitrogen content with additional measurements of phosphorus and potassium. Samples were collected

such that three plant parts, old wood (stems), annual growth (twigs) and leaves could be analyzed for nutrient content. Locations for sample collection consisted of four sites on each of two slope exposures, North and South. Sample locations were selected such that the four sites on each exposure were approximately equally spaced from the top portion of the watershed to the bottom. During each monthly sampling period, individual shrub live oak and mahogany plants were randomly selected at each location and the samples collected. Collected samples were immediately packed in ice and frozen upon return to the university. All material remained frozen until laboratory processing.

Numbers of monthly samples were large. Prior to August 1985, the number of samples being collected each month were 48. In August sampling of manzanita was initiated, resulting in sample numbers increasing to 72/month. Following the October 1985 burn, sampling was suspended until the vegetation began growing the following April. At this time, an extensive area on each exposure (North and South) was selected as a control and sampling of non-burned shrubs continued at the same 72 samples per month rate. However, sampling was initiated to determine nutrient content of burned vegetation at the same time using the pre-burn location criteria as outlined above. This ultimately resulted in an additional 48 samples from annual twigs and leaves of the three shrub species. As a result, following the burn, a total of 120 samples were being collected on a monthly basis. Unfortunately, these numbers exceeded the available resources and

capabilities for laboratory processing.

Laboratory Analysis

Frozen sample material was thawed, separated and prepared for oven drying. These procedures consisted of the following preparations for each field sample collected:

1. Stems (old wood) were thawed and cut up into smaller segments and bagged for subsequent drying and grinding.
2. Leaves were manually separated from twigs and bagged.
3. Annual growth was determined from twig material, separated and bagged.
4. Each treatment (2), plant part (3), species (3), replication (4) and exposure (2) were individually bagged.

Plant samples were oven dried in a forced air oven at 70^0 C for 24 hours prior to grinding. Grinding consisted of using a Wiley mill to grind samples to pass through a 20 mesh screen. Dried and ground sample material was individually stored in either airtight vials or coin envelopes.

Preparation of samples for block digestion consisted of initially oven drying the stored sample material at 50^0 C for approximately one hour so as to remove any previous moisture accumulation from the air. After drying, samples were placed in a sealed desiccator to inhibit moisture accumulation. At this point, a composite sample was weighed into a digestion tube for each treatment, species, plant part and exposure combination. Thus, a composite sample was formed by combining, equally, the

material from the four replications (locations on the watershed). Composite samples were weighed to four decimal places as required for accurate nitrogen determination.

Each digestion conducted involved a maximum of 40 tubes (samples), since only 1 digestion block was available. Whenever a digest was conducted, one or more blanks, replicate samples, and a citrus standard formed part of the digest. The block digestion procedure as outlined by Gray (Appendix A) was used, since this procedure results in digested samples which may be analyzed for nitrogen and mineral elements without further digestion procedures being required. Following digestion, sample material was stored in 100 ml sealed plastic storage flasks at a 1:5 dilution.

The nitrogen content of digested sample material was determined from 20 ml aliquots with the aid of a 1030 Tecator Analyzer. The phosphorus content of a limited number of samples was determined using a Vanadomolybdophosphoric Yellow Color Method and a Bausch & Lomb Spec 20 spectrophotometer (Appendix B). The determination of potassium was anticipated to be measured using the atomic absorption spectrophotometer. However, the lack of manpower, laboratory resources, the large number of samples collected, plus the fact that the atomic absorption spectrophotometer was, and is still, not in working order did not allow these measurements to be made. Thus, phosphorus and potassium measurements are yet to be completed.

RESULTS

Nitrogen

Introduction

During the course of the nutrient analysis phase of the project over 2,000 samples were processed through the laboratory and analyzed for nitrogen content. The data reported (Appendix C) are composed of mean N content of plant material from the Battle Flat study site and, as such, each data value reported is derived from 8 individual samples. During the course of the study, the standard errors for N analysis of leaf, annual twig and stem (old wood) material over all species was determined as averaging 0.058, 0.045 and 0.029%, respectively.

Shrub Live Oak

Nitrogen analysis of shrub live oak plant parts was conducted from April 1985 through April 1987. No sampling occurred from November 1985 through March 1986 as no re-growth occurred following the October 1985 burn until April 1986.

Mean nitrogen content of stems (old wood), twigs (annual growth) and leaves of shrub live oak at the Battle Flat study site are illustrated in Figure 1 and presented in Appendix C. The nitrogen content of the older stem material remained around or slightly below 0.5% both prior and following the burn. Greater variation was apparent in annual twig growth. The high nitrogen content of annual twigs in the control areas (over

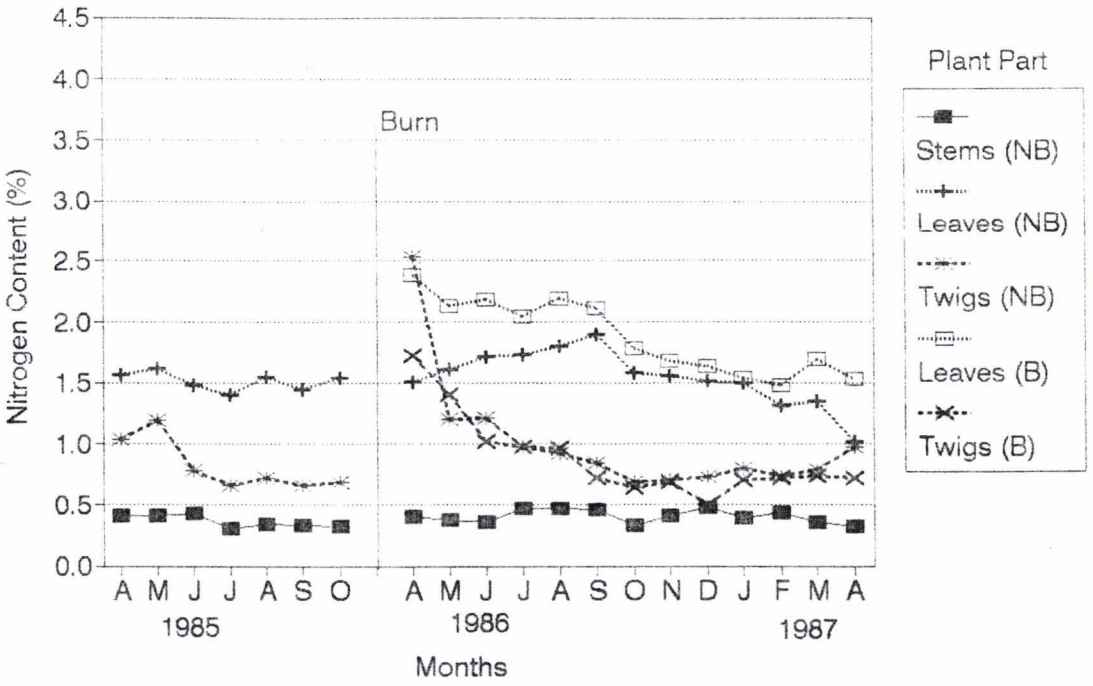

Fig. 1 Mean nitrogen content of shrub live oak plant parts from non-burned (NB) and burned (B) portions of the Battle Flat watershed.

2.5%), when growth commenced in April 1986, may be due to the addition of nitrogen to these areas as a result of runoff. Every attempt was made to avoid control areas where this might occur; however the initial measurement of nitrogen in annual twig growth following the fire was extremely elevated for all species in the control areas. These results suggest that some contamination of the control areas may have occurred. The nitrogen content of annual growth from burned and non-burned oak shrubs showed no appreciable difference following the first month of growth. In fact, both burned and non-burned shrubs demonstrated a decline in nitrogen in annual twigs that reached pre-fire levels (approximately 0.7%) by October 1986. The rise in N content of the non-burned shrubs in April of 1987 was probably due to new growth.

Nitrogen content of oak leaves prior to the burn remained around 1.5%. Following the fire, greater variation occurred in the control area as leaf N content appeared to follow the climatic pattern of the year. An increase in N appeared during the monsoon period due to late summer regrowth. Burned shrubs demonstrated a higher leaf N content which subsequently rapidly declined and approached similar levels as the controls during the fall and winter months. Burned plants maintained higher leaf N content as plants entered the 1987 growing season; however, as these levels are the same as pre-fire levels for 1985, they may be of little significance.

Mountain Mahogany

Mean nitrogen content of the plant parts of mountain mahogany at the Battle Flat study site are illustrated in Figure 2 and presented in Appendix C. Older stems illustrated a fairly stable N content generally slightly above 0.5%. Fluctuations in these data, may be too small to attempt to interpret except as sample variation. There is a slight hint of seasonal variation that may be due to transport mechanisms.

Following the burn, annual growth commenced first on the burned area (April 1986). No annual twig growth was observed on unburned control shrubs until May (Fig. 2). Nitrogen content of annual twig growth was high (around 2.3%) for both burned and non-burned shrubs. These initial data suggest possible movement of N into control areas as mentioned previously when discussing shrub live oak. Initially, following the fire, the pattern of N content in annual twigs demonstrates similarity to shrub live oak. In general, burning did not appear to result in increased N content of annual twig growth as compared to the controls. Following initiation of growth in April-May, the N content of burned and non-burned annual twig growth fell to pre-fire levels by June 1986.

The nitrogen content of mahogany leaves from burned shrubs remained higher than non-burned shrubs throughout the post-burn measurement period (Fig. 2). However, it should be noted that N levels of both burned and non-burned mahogany leaves approached equality during the winter of 1986-87. It appears that increased

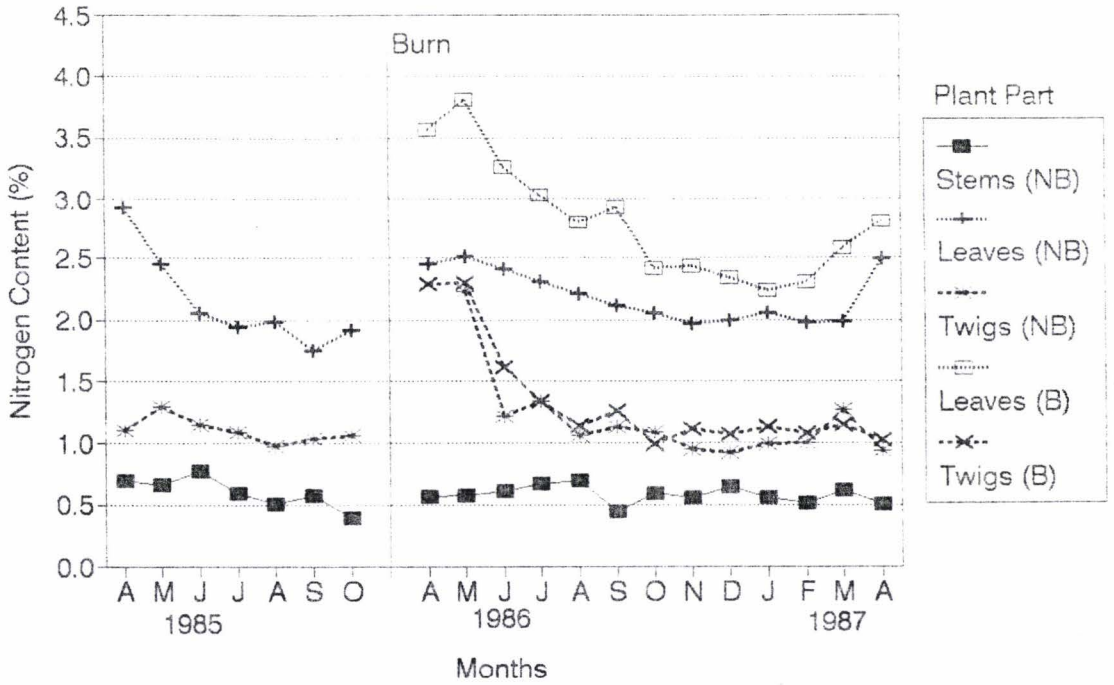

Fig. 2 Mean nitrogen content of mountain mahogany plant parts fron non-burned (NB) and burned (B) portions of the Battle Flat watershed.

N content of leaf material following fire manifested itself over a longer period of time in mountain mahogany than in other species or plant parts. However, by the spring of 1987, the difference between burn and non-burn plants was not great.

Manzanita

The data available for manzanita is more limited (Fig. 3, Appendix C). This is because this species was never part of the research agreement, although it comprised a significant portion of the vegetation on the study site. Pre-fire sampling commenced in August 1985 and measurements of non-burned and seedling shrubs continued through March of 1987.

Nitrogen content of older manzanita stems was quite low (around 0.2 to 0.3%) during much of the study period (Fig. 3).

Annual twigs of manzanita on the unburned control areas demonstrated the same initial rise in N content as did shrub live oak and mountain mahogany following the fire. In fact, the initial increase was greater than the N content of manzanita leaves (Fig. 3). Annual growth of unburned manzanita tended to maintain increased N levels longer than shrub live oak and mountain mahogany. However, by July 1986, these levels were approaching the same amounts as measured prior to the burn.

On the burned area, manzanita seedlings were not identified and collected until July 1986. Evaluations of N content of annual twig growth from seedlings demonstrated little difference from that of mature unburned shrubs (Fig. 3).

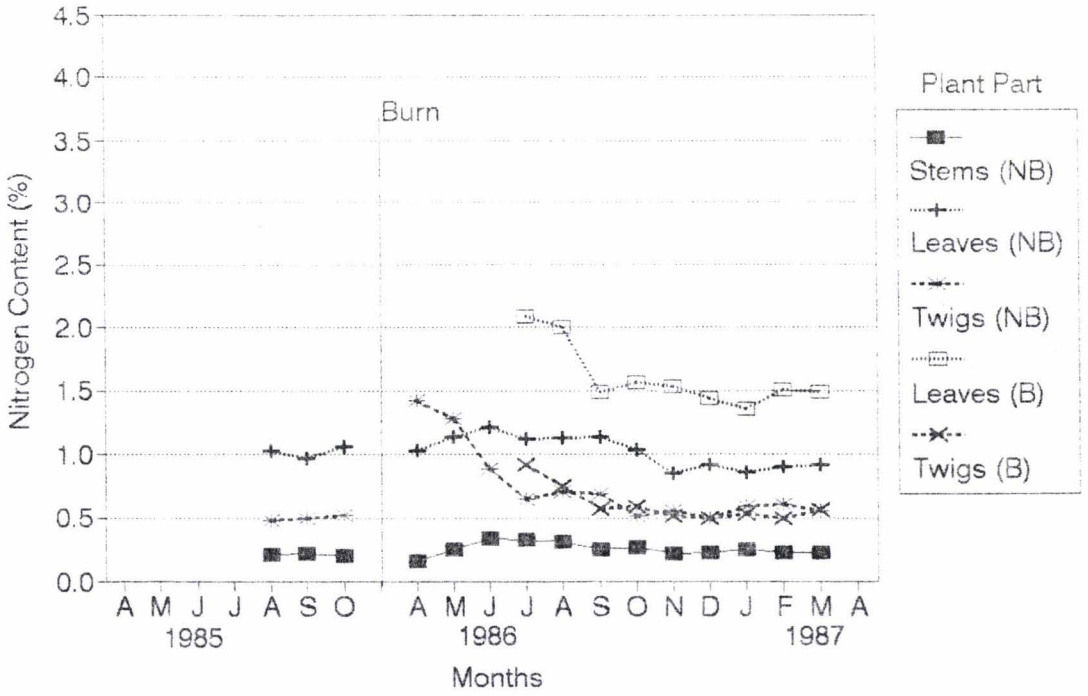

Fig . 3 Mean nitrogen content of manzanita plant parts from non-burned (NB) and burned (B) portions of the Battle Flat watershed.

As with other species, the greatest relative N response to fire occurred in manzanita leaves. Although N levels were generally low for all manzanita plant parts, the increase in leaf N following fire maintained itself throughout the measurement period. These results are generally in contrast to those obtained from shrub live oak and differ in magnitude from mountain mahogany.

Species - Plant Parts

The N content of plant parts for the three predominant shrub species at Battle Flat demonstrate differences due to species.

Mean N content of shrub stems (old wood) by species during the measurement period is presented in Figure 4. Since no older stems had time to develop following the fire, all data pertain to non-burned shrubs. Mountain mahogany maintained the highest stem N content (varying around 0.6%). Shrub live oak tended to vary around 0.4% while manzanita was lowest at a little over 0.2%.

Nitrogen content of annual twig growth is presented in Figure 5. This figure illustrates results from burned as well as non-burned areas for each species. Patterns existing between burned and non-burned shrubs are as presented previously for each species and the interpretations would remain the same. Generally, with one exception, immediately following the burn, the N content of annual twigs followed the same order as stems i.e., mountain mahogany first followed by shrub live oak and finally manzanita. The exception is due to non-burned shrub live oak

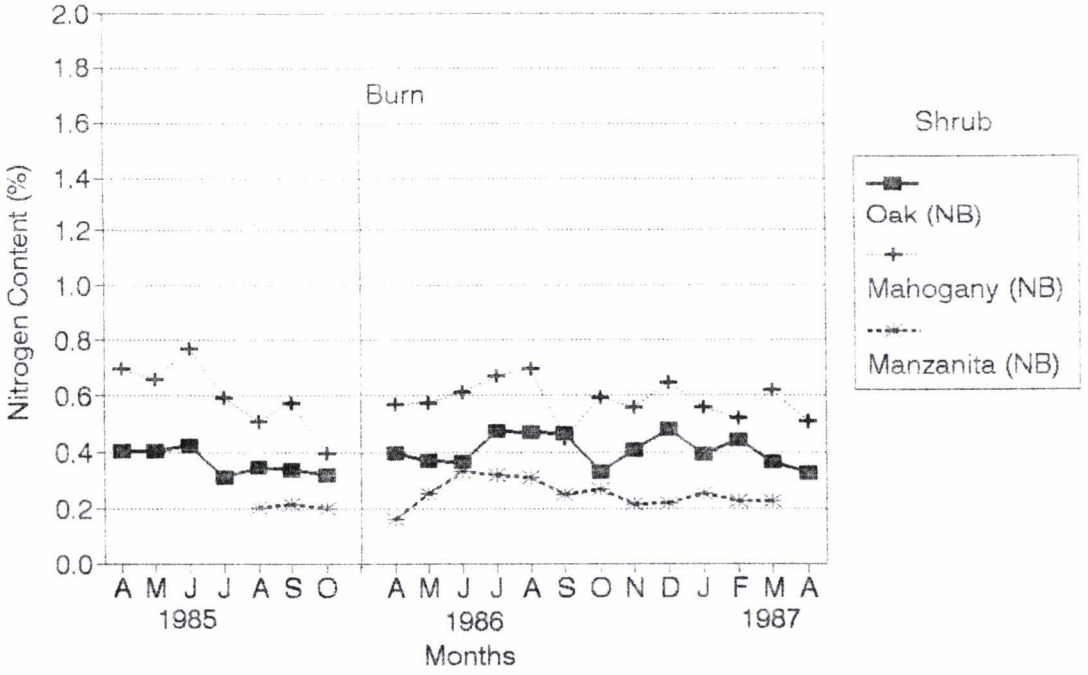

Fig. 4. Nitrogen content of shrub stems (old wook) of shrub live oak, mountain mahogany and mazanita before and after fire on the Battle Flat watershed. All data from non-burned (NB) shrubs.

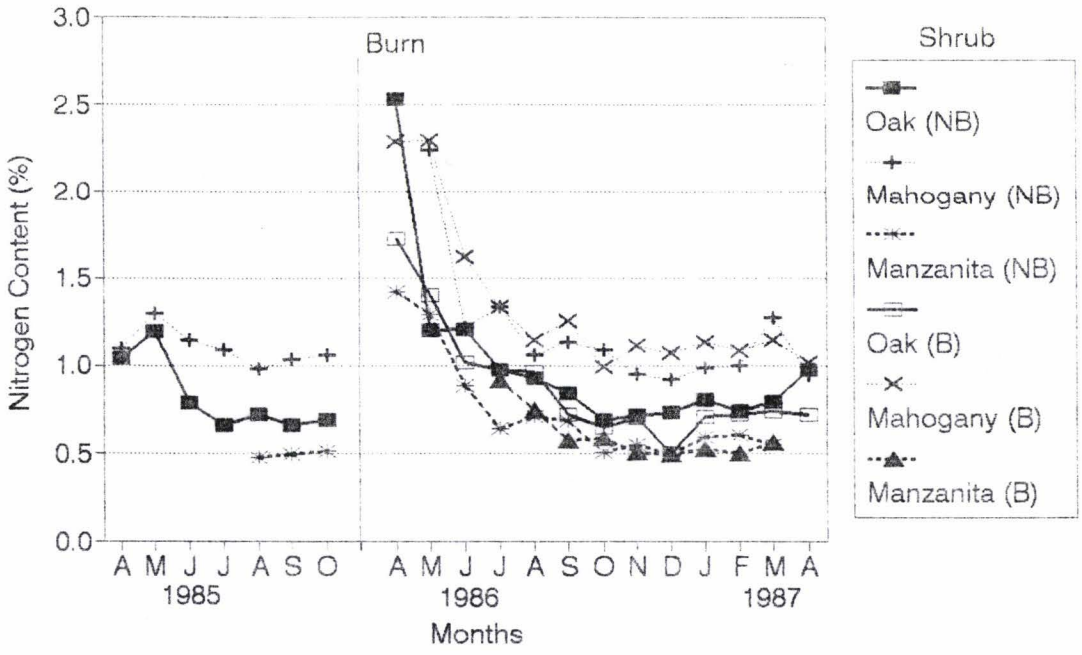

Fig. 5. Nitrogen content of annual twigs from shrub live oak, mountain mahogany and mazanita before and after fire on the Battle Flat watershed. Data from burned (B) and non-burned (NB) shrubs.

measured when re-growth occurred following the fire. This measurement, in excess of 2.5%, was the highest mean N measured for annual growth during the course of the study. As pointed out earlier, these values for annual growth of non-burned shrubs during April of 1986 are unusual and suspect.

The pre- and post-fire N content of leaves for the three major shrub species is presented in Figure 6. Based on the results obtain from other plant parts, it is not surprising that higher leaf N content was associated with mountain mahogany, followed by shrub live oak and manzanita, respectively.

Other Species

Following the first growing season after the October 1985 burn, additional sampling of plant species inhabiting the burned area was conducted during November 1986. Although no sampling or analysis of these species was allowed for in the study agreement, some had either appeared or increased following the burn and it was felt important to determine the N content of these species at least once during the course of the study.

A total of seven species were measured (Table 1). All individuals collected and analyzed were from the burned areas where sampling normally occurred. Little interpretation of the data can be made, since the N content for these species was not collected over time. However, they may be compared to each other and compared with shrub live oak, mountain mahogany and mazanita at the same time period.

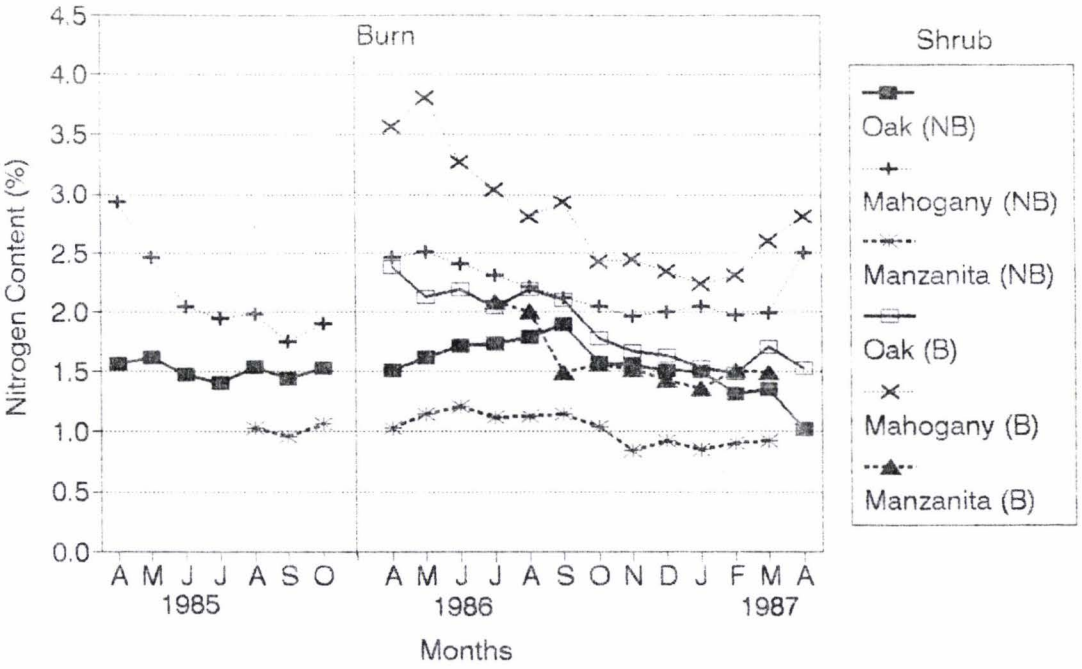

Fig. 6. Nitrogen content of shrub leaves from shrub live oak, mountain mahogany and manzanita before and after fire on the Battle Flat watershed. Data from burned (B) and non-burned (NB) shrubs.

Table 1. Mean nitrogen content (%) of plant parts from seven plant species collected from burned sample locations (Nov. 1986, N = 4).

Plant Species	Plant Part	Nitrogen Content
Ceanothus	Annual Twigs	0.93
	Leaves	2.18
Rhamnus	Annual Twigs	0.67
	Leaves	1.63
Skunkbrush	Annual Twigs	0.95
	Leaves	1.13
Sugar Sumac	Annual Twigs	0.59
	Leaves	1.03
Wright's Silktassel	Annual Twigs	0.44
	Leaves	1.40
Weeping Lovegrass	Leaves & Stems	1.21
Yerba-santa	Annual Twigs	0.74
	Leaves	1.63

Phosphorus

Due to events and restrictions presented earlier, only limited phosphorus analysis has been possible to date. The data presented below (Table 2), consist only of pre-fire information covering May and June 1985. Unfortunately, too few samples have been processed to allow any interpretation. It is expected that this analysis will be completed once personnel and laboratory facilities become available.

Table 2. Mean Phosphorus content (%) of shrub live oak and mountain mahogany plant parts (May & June 1985 - Pre-fire).

Sample Date	Plant Species	Plant Part	N	Phosphorus
May 1985	Oak	Stems	8	0.026
May 1985	Oak	Annual Twigs	8	0.113
May 1985	Oak	Leaves	8	0.146
May 1985	Mahogany	Stems	8	0.031
May 1985	Mahogany	Annual Twigs	8	0.124
May 1985	Mahogany	Leaves	8	0.153
June 1985	Oak	Stems	8	0.028
June 1985	Oak	Annual Twigs	4	0.065
June 1985	Oak	Leaves	5	0.100

CONCLUSIONS

Results from N analysis of three species, shrub live oak, mountain mahogany, and manzanita from the Battle Flat study site indicate that the effects of fire on plant N content were minimal. Generally, it is assumed, that when fire occurs, there is a "fertilizer" effect. That is, nitrogen, locked up in vegetation, is released and made available, through several processes, for new plant growth. This available N is usually measured in increased N content of vegetation after fire and manifests itself for several years before returning to pre-fire levels. Results from the Battle Flat study area did not conform to this "traditional expectation".

The response of the three predominant shrub species to fire was minimal as far as nitrogen content was concerned. Initial increases were observed in annual twig growth and leaves; however, the initial increase in N content of annual twigs decreased rapidly to pre-fire levels within the first year following fire. Leaf content of N illustrated a slower decline following fire; however, the trend was similar to that of annual twigs. Older wood (stems) could not be measured during the time frame of the study, except under pre-fire and control conditions. As expected, these data provide no insight into post-fire vegetation response.

The effect of fire on the dynamics of nitrogen as affected by subsequent runoff and sediment accumulation was measured by

the Forest Service, but that data is unavailable for this report. Consequently, certain assumptions must be made in order to explain the results obtained from this study.

The Battle Flat study area is characterized by north and south exposure slopes that are quite steep over much of the study area. Subsequent rains following the October 1985 burn undoubtedly moved non-volatized nitrogen either into the soil or down and off the watershed. Although a sediment pond was positioned to catch runoff from the watershed, it was observed, by the principal investigator, that runoff breached the sediment pond following the burn and prior to the next growing season. It is possible that significant amounts of N were lost from this ecosystem due to volatization and runoff prior to vegetation growth. If such were the case, limited amounts of N would be available for vegetation re-growth and would be rapidly depleted when re-growth occurred. If this were the situation, the results obtained from nitrogen analysis of the Battle Flat watershed would be completely explained. Consequently, the use of fire under circumstances of steep slopes and when the possibility of heavy rainfall and runoff may occur, could not be considered a desirable management decision.

Evaluation of N data from additional species or P data from shrub live oak and mountain mahogany is difficult, if not impossible, due to the present unavailability of additional information.

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APPENDIX A

PROCEDURES FOR BLOCK DIGESTION OF PLANT SAMPLES

BLOCK DIGESTION OF PLANT SAMPLES FOR ANALYSES OF NITROGEN AND MINERAL ELEMENTS

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INTRODUCTION

Recent improvements in wet oxidation procedures using H_2SO_4 and H_2O_2 have made possible the rapid analysis of plant samples for nitrogen and mineral elements. Early work of Cotton[3], Lindner[9], Lindner and Hardy[10] and Lowther[11] with H_2O_2-H_2SO_4 digestion demonstrated that N, P, K, Ca and Mg could be determined in the same digest without a catalyst. Bradstreet[1] and Florence and Milner[5] also used H_2O_2 oxidation without a catalyst. Bould[2], Bradford[1], and O'Neill and Webb[12] studied the use of selenium as a catalyst. Cresser and Parsons[4] and Van Lierop[17] studying $HClO_4$ in plant digestion reported that it causes loss of nitrogen even when used in small amounts. Van Lierop[17] reported, however, that $HClO_4$ and H_2O_2 do not oxidize NH_4^+ in the presence of organic matter. Isaac and Johnson[8], Smith[14], Thomas, Sheard and Moyer[15] and Warner and Jones[18] compared the H_2SO_4-H_2O_2-Se system with conventional procedures and found it suitable for determination of N and several mineral elements with a single digest. Parkinson and Allen[13] developed a digestion solution that used H_2O_2, Li_2SO_4 and Se in small Kjeldahl flasks and found it suitable for the determination of N, P, K, Na, Ca, Mg, Zn, Fe, Mn and Cu. Gallaher et al[6] and Tucker[16] designed digestion blocks that used one inch diameter digestion tubes that enabled large numbers of samples

to be processed at the same time.

Haynes[7] compared the H_2O_2 - Li_2SO_4-Se and H_2SO_4-Na_2SO_4 modified digestion solutions with the conventional HNO_3-$HClO_4$ wet digestion and a dry ashing procedure. Mean values for P, K, Ca and Mg by the four methods were in good agreement with quite similar precision of the data. Close agreement of N contents by the two modified procedures with a conventional Kjeldahl procedure was also obtained.

The digestion block described in this paper was patterned after that of Tucker[16] because it could accommodate a large number of tubes and be used on a hot plate that is commonly used in most laboratories. The digestion procedure described here is an adaptation of the procedure described by Parkinson and Allen so that it could be used in one inch diameter tubes. An advantage of this adaptation is that no cooling periods are required between reagent additions and that a complete digestion can be completed in 2 1/2 hours.

C A U T I O N

If a digestion tube should crack while in the block, acid can drain out and react with the metal to form hydrogen gas. If the space is sealed around the tube, this gas can expand to blow out the tube. Take great care to remove all tubes that are cracked, always wear a face shield.

DIGESTION AND ANALYSIS OF PLANT SAMPLES

I. Block Digestion Procedure

A. Equipment

1. Hot plate
   220 Volt, 2800 Watts, 11" X 19", with top cover removed.
2. Digestion block
   An aluminum metal block, 2" X 11" X 19" sits on asbestos strips in the same position over the heating elements as was the original cover. Three rows of holes with 7 holes per row are arranged over each heating element. Each hole is 1 1/16" in diameter to loosely hold digestion tubes 25 mm in diameter. The final pattern is 12 holes wide and 7 holes deep with 21 holes over each heating element for a total of 84. A small hole is drilled to hold a thermometer.

3. Digestion tubes
   Heavy walled tubes such as Pyrex or Kimax 25 X 200 mm culture tubes. Thin walled test tubes are unsatisfactory. Tubes are to be calibrated and marked at a volume of 50 ml.

4. Syringe type dispensers
   Glass barrel with teflon plunger and tip.
   A. 10 ml (to deliver 7.0 ml aliquot)
   B. 4 ml (to deliver 2.5 ml aliquot)

B. Reagents

1. Solution A
   Place a 1 liter pyrex beaker in an ice bath in the hood and add the following reagents in order:

   ~~1.50 g. Selemium~~ Metal 2.11 g SeO_2
   8.00 g. $Li_2SO_4.H_2O$
   205 ml Conc.H_2SO_4
   415 ml 30% H_2O_2 (Cautiously in increments. Considerable heat and frothing is produced)

2. Solution B
   Place a 1 liter pyrex beaker in the hood and add the following reagents in order:
   35 ml Conc. H_2SO_4
   2.5 ml 60% $HCLO_4$ (optional)
   415 ml 30% H_2O_2

C. Procedure for digestion of plant samples

1. Weigh 0.500 g dried, ground plant samples into 25 X 200 mm digestion tubes.
2. Turn on hot plate to highest temperature. Place 260 C thermometer in hole in block.

3. When block temperature reaches 190 to 200 C, place sample tubes in the back 2 rows of the block. (Highest tube no. in last hole).

4. With the 10 ml syringe dispenser, add 7.0 ml soln. A to each tube on the back row. (Wear face shield).

5. Add another row of tubes (third row from the back).

6. Add 7.0 ml soln. A to tubes in second row from back.

7. Continue adding rows of tubes and digestion soln. A one row at a time till the last tube on the front row has been completed.

8. About 12 to 15 minutes after the beginning of digestion frothing has ceased, solutions turn dark brown to black, most of the water vapor has been driven off and white fumes begin to form.

   Carefully add 2.5 ml solution B down the sides of the tubes (start at the back row and move forward).

9. After 10 to 20 minutes when white fumes again begin to form, add a second 2.5 ml aliquot of solution B.

10. Continue heating at maximum setting for 2 1/2 hrs. from the start of the digestion. Turn off heat and allow to cool in the hood.

11. Removed cooled tubes (handle with rubber gloves) and make to 50 ml. mark with distilled water. Shake or stir well.

12. Use diluted digests directly for analyses.

II. Determination of N, P, K, Ca, Mg, Zn, Fe & Mn in digests.

N - Ammonia Electrode
P - Mo-V Colorimetric
K - Flame Photometer
Ca, Mg, Zn
AAS
Fe, Mn, Cu

A. Stock Solns.

1. Nitrogen (NH_4+) - 5000 ppm N
   Transfer 5.8962 g dried $(NH_4)_2SO_4$ to a 250 ml vol. flask, add 2 drops conc H_2SO_4 and make to vol. with distilled water.

2. Phosphorus - 500 ppm P
   Transfer 2.1950 g dried KH_2PO_4 to a 1 L vol. flask

and make to vol. with distilled water.

3. Potassium - 5000 ppm K
   Transfer 9.5342 g KCl to a 1 L. vol. flask and make to vol. with distilled.

4. Calcium - 6250 ppm Ca
   Transfer 1.5625 g $CaCO_3$ to a 100 ml vol. flask. Add conc. HCl dropwise till $CaCO_3$ is dissolved. Make to vol. with distilled water.

5. Magnesium - 2500 ppm Mg
   Place 0.2500 g magnesium metal in a 100 ml vol. flask. Add conc. HCl dropwise till all the metal is dissolved. Make to vol. with distilled water.

6. Zinc - 1000 ppm Zn
   Place 1.0000 g zinc metal in a 1 L. vol. flask. Add a few ml conc. HCl till metal is dissolved. Make to vol. with distilled water.

7. Iron - 1000 ppm Fe
   Place 1.0204 g iron metal (98% purity) in a 1 L. vol. flask and dissolve in a few ml. of conc. HCl. Make to vol. with distilled water. Store under a layer of mineral oil.

8. Manganese - 1000 ppm Mn
   Transfer 3.0764 g dried $MnSO_4.H_2O$ to a 1 L. vol. flask. Add 1 ml conc. H_2SO_4 and make to vol. with distilled water. Store under a layer of mineral oil.

9. Copper - 1000 ppm Cu
   Place 1.0000 g copper metal in a 1 L. vol. flask and dissolve in a few ml of conc. HNO_3 to make vol. with distilled water. Store in a glass container.

B. Working solutions

Element	Stock Soln.	ml Stock soln. in 100 ml. vol.	Final conc. (ppm) of element
N	5000 ppm N	----	5000
P	500 ppm P	----	500
K	5000 ppm K	----	5000
Ca	6250 ppm Ca	10	625
Mg	2500 ppm Mg	10	250
Zn	1000 ppm Zn	2.5	25
Fe	1000 ppm Fe	2.5	25
Mn	1000 ppm Mn	5.0	50
Cu	1000 ppm Cu	1.0	10

Store copper soln. in a glass container.

C. Standard solutions

Element	Working soln. added to 50 ml digestion tubes	Final conc. of element in digest
N	2 ml 5000 ppm N	200 ppm N [1/]
P	0.5 ml 500 ppm P	5 ppm P
	1.0 " "	10 ppm P
	1.5 " "	15 "
	2.0 " "	20 "
	2.5 " "	25 "
	3.0 " "	30 "
	3.5 " "	35 "
	4.0 " "	40 "
	5.0 " "	50 "
K	10 ml 5000 ppm K	1000 ppm K
Ca	2.0 ml 625 ppm Ca	25 ppm Ca
Mg	2.0 ml 250 ppm Mg	10 ppm Mg
Zn	1.0 ml 25 ppm Zn.	0.5 ppm Zn
	2.0 " "	1.0 " "
Fe	2.0 ml 25 ppm Fe	1.0 ppm Fe
	4.0 ml "	2.0 ppm Fe
Mn	1.5 ml 50 ppm Mn	1.5 ppm Mn
	3.0 " "	3.0 " "
Cu	1.0 ml 10 ppm Cu	0.2 ppm Cu
	2.0 " " " "	0.4 " "

The standard solutions in digestion tubes are carried through the digestion procedure with blanks in the same manner as the samples. New standards should be prepared weekly.

1/ DO NOT USE SOLN. B IN N STANDARDS.

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APPENDIX B

PHOSPHORUS DETERMINATION FROM PLANT DIGESTS

PROCEDURE: Soils Laboratory - Phosphorus determination for plant digests using H_2SO_4, H_2O_2, SeO_2, and $LiSO_4$

VANADOMOLYBDOPHOSPHORIC YELLOW COLOR METHOD

Jackson, M.L. 1958. Soil chemical analysis. Prentice-Hall, Inc. Sixth printing, 1970 by author, Dept. of Soil Science, Univ. of Wisconsin. Madison, WI. (pages 151-153)

Olsen, S.R., and L.E. Sommers. 1982. Phosphorus. Agronomy 9(part 2):403-430. 2nd Edition. (pages 418-419).

1. Color Development Agent - to obtain 1 liter of the color developing agent:

   A. Solution A
      1. Weigh 25.0 grams of ammonium paramolybdate [$(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$] into a clean 600 ml beaker.
      2. Add 400 ml of deionized water.
      3. Stir on a stirring plate.

   B. Solution B
      1. Place 275 ml of deionized water in a 1000 ml beaker and bring to a slow boil while stirring.
      2. Slowly add 1.25 grams of ammonium metavanadate [NH_4VO_3] to the boiling water while stirring.
      3. Cool the solution to room temperature by placing the solution in a water bath.
      4. Slowly add 250 ml of concentrated HNO_3 from a graduated cylinder. BE SURE TO DO THIS STEP UNDER A HOOD WITH A STRONG HOOD FAN.
      5. Cool the solution to room temperature by placing the solution in a water bath.

   C. Color Developing Solution
      1. Using deionized water, quantitatively transfer Solution A to a 1 liter volumetric flask. Be careful not to use too much water or you will exceed the final volume.
      2. Using deionized water, quantitatively transfer Solution B to the flask containing Solution A.
      3. Stir well and allow the solution to come to room temperature before bringing to final volume.
      4. This solution will deteriorate after one week.
      5. If you are planning to continue the procedure, transfer the solution to a brown colored repipette bottle that has a pipette capable of delivering 10 ml.
      6. Set the repipette for 10 ml and calibrate the delivery using a graduated cylinder.

II. Preparing the spectophotometer (Bausch & Lomb Spec 20).

A. Before turning on the instrument:
   1. Set the wavelength to 470 mu.
   2. Remove the red filter if it is present. Handle the filter with tissue paper. Touching it will scratch it.
   3. Check to see if the tube with the blue shield is in place. The tube with the black dot on the shield is used for wavelengths greater than 600 mu. The correct tube for this procedure is CE-A59RX.

B. Turn on the Spec 20 about 15 to 20 minutes before use and set the needle to about 30% transmittance. This prevents damage to the instument while warming.

III. Preparation of standard curve:

A. Create a series of standards containing 0, 2, 4, 6, 8, 10, and 15 ug P/ml of solution.
   1. These standards are created by pipetting given amounts of a 50 ug P/ml primary standard. An example of the calculations is as follows:

WORKING STANDARD		PRIMARY STOCK
(concentration) x (volume)	=	(conc) x (vol)
(2 ug/ml) x (50 ml)	=	(50 ug P/ml) x (X ml)
X ml	=	2 ml of primary stock into a 50 ml volumetric

   a. Pour 45-50 ml of the 50 ug P/ml primary standard into a clean 100 ml beaker.
   b. Obtain seven clean 50 ml volumetric flasks and a set of clean calibrated glass pipettes (2, 3, 4, 5, and 10 mls).
   c. Using the glass pipettes, transfer the following amounts of the 50 ug P/ml primary standard to the labelled 50 ml volumetric flasks:

flask label	ml of primary std to add
0 ug/ml	0 ml
2 ug/ml	2 ml
4 ug/ml	4 ml
6 ug/ml	6 ml
8 ug/ml	8 ml
10 ug/ml	10 ml
15 ug/ml	15 ml

2. To each standard created above, add an _____ ml alloquat of a blank from the digestion process. This insures that the standards will contain the same materials as the samples. It will help eliminate interferences from the chemicals in the digest.
3. Swirl the solution in each flask.
4. Add 10 ml of the color developing agent from the repipette.
5. Bring each standard to volume with deionized water.
6. Parafilm and invert each standard several times to mix.

B. Determination of % transmittance for standards:
1. Allow the standards to set for 10 minutes after mixing.
2. Set the Spec 20 to zero using the knob on the left.
3. Obtain a clean cuvette. Be sure to check for scratches on the lower half.
4. Fill the cuvette about one third full with the 0 ug P/ml standard. Wipe the cuvette clean of finger prints with a piece of cheese cloth.
5. Set the Spec 20 to 100% using the 0 ug P/ml standard and the knob on the right.
6. Rinse the cuvette with the next standard, repour the standard and record the % transmittance.
7. Repeat Step 6 until all standards are read.

C. Plotting the standard curve:
1. Using single cycle semilog graph paper, plot the percent transmittance on the y axis and the concentrations of the standards on the x axis.
2. If the line is not straight or contains points that deviate from it, then make the standards again (from step III.A).
3. Do not turn off the Spec 20 or the standards must be read and plotted again!

IV. Analysis of samples

A. Preparation of samples
1. You will need one clean 50 ml volumetric for each sample. This volumetric does not have to be dry.
2. Into a 50 ml volumetric, accurately pipette a _____ ml alloquat of the sample. Use a calibrated volumetric glass pipette.
3. Repipette 10 ml of the color developing solution into the sample and swirl.
4. Bring the sample to volume with deionized water.
5. Parafilm and invert several times to mix.
6. Allow to set for 10 minutes while color develops.
7. Using the same cuvette that was used for the standards, read and record the transmittance for each sample.
8. Use the next sample to wash the cuvette each time.

APPENDIX B

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PROCEDURE: Soils Laboratory - Phosphorus determination for plant digests using H_2SO_4, H_2O_2, SeO_2, and $LiSO_4$

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A. Create a series of standards containing 0, 2, 4, 6, 8, 10, and 15 ug P/ml of solution.
   1. These standards are created by pipetting given amounts of a 50 ug P/ml primary standard. An example of the calculations is as follows:

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   a. Pour 45-50 ml of the 50 ug P/ml primary standard into a clean 100 ml beaker.
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2. To each standard created above, add an _____ ml alloquat of a blank from the digestion process. This insures that the standards will contain the same materials as the samples. It will help eliminate interferences from the chemicals in the digest.
3. Swirl the solution in each flask.
4. Add 10 ml of the color developing agent from the repipette.
5. Bring each standard to volume with deionized water.
6. Parafilm and invert each standard several times to mix.

B. Determination of % transmittance for standards:
1. Allow the standards to set for 10 minutes after mixing.
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3. Repipette 10 ml of the color developing solution into the sample and swirl.
4. Bring the sample to volume with deionized water.
5. Parafilm and invert several times to mix.
6. Allow to set for 10 minutes while color develops.
7. Using the same cuvette that was used for the standards, read and record the transmittance for each sample.
8. Use the next sample to wash the cuvette each time.

B. Determination of the percent P for each sample.

1. Obtain the graph value for each sample by plotting the % transmittance for each sample on the standards graph.

2. Use the following equation to obtain the percent P:

$$\% P = \frac{(\text{graph value, ug/ml}) \times 50 \text{ ml} \times 100 \text{ ml}}{(\text{ml of alloquat}) \times (\text{sample weight, g})} \times 10^{-6} \text{g/ug} \times 100$$

3. The above equation can be simplied by combining terms:

$$\% P = \frac{(\text{graph value})}{(\text{ml of alloquat}) \times (\text{sample weight})} \times 0.5$$

4. NOTE: The above equations can only be used when the plant digest has been completed using the 100 ml tubes. If the 75 ml tubes are used the equation must be altered.

B. Determination of the percent P for each sample.

1. Obtain the graph value for each sample by plotting the % transmittance for each sample on the standards graph.

2. Use the following equation to obtain the percent P:

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4. NOTE: The above equations can only be used when the plant digest has been completed using the 100 ml tubes. If the 75 ml tubes are used the equation must be altered.

APPENDIX C

NITROGEN CONTENT OF SHRUBS AT BATTLE FLAT

Shrub Live Oak

Sample Date	Mean Non - Burn Stems	Annual	Leaves	Mean - Burn Annual	Leaves
April 1985	0.405	1.04	1.565		
May	0.405	1.19	1.620		
June	0.425	0.78	1.475		
July	0.310	0.66	1.405		
August	0.345	0.72	1.545		
Sept.	0.335	0.66	1.445		
October	0.320	0.69	1.535		
Watershed	Burned				
April 1986	0.395	2.53	1.510	1.72	2.38
May	0.370	1.20	1.615	1.40	2.13
June	0.365	1.21	1.710	1.02	2.19
July	0.475	0.97	1.730	0.97	2.04
August	0.470	0.93	1.795	0.96	2.19
September	0.465	0.84	1.895	0.72	2.11
October	0.330	0.69	1.580	0.65	1.78
November	0.410	0.71	1.555	0.70	1.68
December	0.480	0.73	1.515	0.50	1.64
January 1987	0.390	0.81	1.500	0.71	1.54
February	0.440	0.74	1.315	0.72	1.48
March	0.365	0.79	1.345	0.74	1.70
April	0.325	0.98	1.020	0.72	1.53

Mountain Mahogany

Sample Date	Mean - Non-Burn Stems	Annual	Leaves	Mean - Burn Annual	Leaves
April 1985	0.695	1.10	2.935		
May	0.660	1.30	2.455		
June	0.770	1.15	2.050		
July	0.590	1.09	1.945		
August	0.510	0.98	1.985		
September	0.575	1.03	1.755		
October	0.395	1.06	1.910		
Watershed	Burned				
April 1986	0.570	No Growth	2.455	2.29	3.57
May	0.575	2.24	2.510	2.30	3.81
June	0.615	1.22	2.405	1.62	3.27
July	0.670	1.34	2.305	1.33	3.04
August	0.695	1.06	2.210	1.14	2.81
September	0.445	1.13	2.120	1.26	2.94
October	0.590	1.09	2.050	0.99	2.42
November	0.560	0.95	1.965	1.11	2.44
December	0.645	0.92	2.000	1.07	2.35
January 1987	0.560	0.99	2.050	1.13	2.24
March	0.520	1.00	1.975	1.09	2.31
April	0.620	1.27	1.990	1.15	2.59